

IN THE CLAIMS:

Claim 1. (PREVIOUSLY PRESENTED) Apparatus for heart pacing with hemodynamic improvement, comprising:

one or more electrodes, which are adapted to convey electrical signals to respective cardiac muscle segments; and

signal generation circuitry, which applies an extended pacing signal, having an overall duration greater than 8 ms, to the one or more electrodes so as to pace the heart.

Claim 2. (ORIGINAL) Apparatus according to Claim 1, wherein the overall duration is at least 10 ms.

Claim 3. (ORIGINAL) Apparatus according to Claim 2, wherein the overall duration is at least 20 ms.

Claim 4. (ORIGINAL) Apparatus according to Claim 1, wherein the overall duration is less than approximately 100 ms.

Claim 5. (PREVIOUSLY PRESENTED) Apparatus according to Claim 1, wherein the cardiac muscle segments to which the one or more electrodes are adapted to be applied are characterized by a refractory period, and wherein the overall duration of the signal is such that the signal terminates during the refractory period.

Claim 6. (ORIGINAL) Apparatus according to Claim 1, wherein the signal has a leading edge and a trailing edge, and wherein the trailing edge is characterized by an absolute rate of voltage change substantially smaller than that of the leading edge.

Claim 7. (ORIGINAL) Apparatus according to Claim 6, wherein the absolute rate of the voltage change is less than a minimum rate of change necessary to generate an action potential in the cardiac muscle segments.

Claim 8. (ORIGINAL) Apparatus according to Claim 1, wherein the signal has an amplitude at least three times as great as a threshold for pacing the heart, but not sufficient for cardioversion.

Claim 9. (ORIGINAL) Apparatus according to Claim 8, wherein the signal has a duration at least three times a threshold duration for pacing the heart at the amplitude of the signal.

Claim 10. (ORIGINAL) Apparatus according to Claim 1, wherein the extended pacing signal comprises a train of pulses.

Claim 11. (ORIGINAL) Apparatus according to Claim 10, wherein each of the pulses in the train has a pulse duration of at least 1 ms.

Claim 12. (ORIGINAL) Apparatus according to Claim 10, wherein the pulse train has a period of at least 5 ms.

Claim 13. (ORIGINAL) Apparatus according to Claim 12, wherein the pulse train has a period of at least 20 ms.

Claim 14. (ORIGINAL) Apparatus according to Claim 10 wherein the train of pulses comprises a plurality of biphasic pulses.

Claim 15. (ORIGINAL) Apparatus according to Claim 10, wherein the train of pulses has a duty cycle between about 10% and 50%.

Claim 16. (WITHDRAWN) Apparatus for heart pacing with hemodynamic improvement, comprising:

one or more electrodes, which convey electrical signals to respective cardiac muscle segments; and

signal generation circuitry, which applies an extended pacing signal, comprising a train of a plurality of biphasic pulses, to the one or more electrodes so as to pace the heart.

Claim 17. (WITHDRAWN) Apparatus according to Claim 16, wherein each of the pulses in the train has a pulse duration of at least 1 ms.

Claim 18. (WITHDRAWN) Apparatus according to Claim 16, wherein the pulse train has a period of at least 5 ms.

Claim 19. (WITHDRAWN) Apparatus according to Claim 18, wherein the pulse train has a period of at least 20 ms.

Claim 20. (WITHDRAWN) Apparatus according to Claim 16, wherein the train of pulses has a duty cycle between about 10% and 50%.

Claim 21. (WITHDRAWN) Apparatus according to Claim 16, wherein the train of pulses comprises square wave pulses.

Claim 22. (WITHDRAWN) Apparatus according to Claim 16, wherein the train of pulses comprises sinusoidal pulses.

Claim 23. (WITHDRAWN) Apparatus for heart pacing with hemodynamic enhancement, comprising:

one or more electrodes, which convey electrical signals to respective cardiac muscle segments; and

signal generation circuitry, which applies an extended pacing signal to the one or more electrodes so as to pace the heart, the signal having an amplitude at least three times as great as a threshold for pacing the heart, but not sufficient for cardioversion.

Claim 24. (WITHDRAWN) Apparatus according to Claim 23, wherein the signal has a duration at least three times a threshold duration for pacing the heart at the amplitude of the signal.

Claim 25. (WITHDRAWN) Apparatus according to Claim 1, wherein application of the extended pacing signal modifies a characteristic of pulsatile flow of blood in the heart.

Claim 26. (WITHDRAWN) Apparatus according to Claim 25, wherein the application of the extended pacing signal increases a stroke volume of the heart by at least 5% relative to the stroke volume when the heart is paced with pulses less than 2 ms in duration.

Claim 27. (WITHDRAWN) Apparatus according to Claim 26, wherein the application of the extended pacing signal increases the stroke volume by at least 10% relative to the stroke volume when the heart is paced with pulses less than 2 ms in duration.

Claim 28. (WITHDRAWN) Apparatus according to Claim 25, wherein the application of the extended pacing signal modifies a cardiac output of the heart by at least 5% relative to the cardiac output when the heart is paced with pulses less than 2 ms in duration at a pacing rate equal to that of the extended pacing signal.

Claim 29. (WITHDRAWN) Apparatus according to claim 25, wherein the application of the extended pacing signal increases a contractility of at least a portion of the heart by at least 10% relative to the contractility thereof when the heart is paced with pulses less than 2 ms in duration.

Claim 30. (WITHDRAWN) Apparatus according to Claim 25, wherein the application of the extended pacing signal decreases a contractility of at least a portion of the heart by at least 10% relative to the contractility thereof when the heart is paced with pulses less than 2 ms in duration.

Claim 31. (WITHDRAWN) Apparatus according to Claim 25, wherein the application of the extended pacing signal modifies a muscular tension in the heart by at least 10% relative to the tension when the heart is paced with pulses less than 2 ms in duration.

Claim 32. (WITHDRAWN) Apparatus according to Claim 1, wherein application of the extended pacing signal modifies the duration of an action potential in the respective cardiac muscle segments by at least 10% relative to the duration when the heart is paced with pulses less than 2 ms in duration.

Claim 33. (WITHDRAWN) Apparatus according to Claim 1, wherein the signal generation circuitry comprises a pulse generator and a DC offset generator, whose outputs are summed to provide the extended pacing signal.

Claim 34. (WITHDRAWN) Apparatus according to Claim 1, wherein the one or more electrodes comprise a plurality of electrodes, which are positioned in different chambers of the heart.

Claim 35. (WITHDRAWN) Apparatus according to Claim 34, wherein the signal comprises a plurality of waveforms, which are applied respectively to the electrodes in the different chambers according to a predetermined time sequence.

Claim 36. (WITHDRAWN) Apparatus according to Claim 34, wherein a pacing pulse having a duration less than 8 ms is applied to one or more of the electrodes positioned in a first one of the different chambers, and wherein the extended pacing signal is applied to another one or more of the electrodes positioned in a second one of the different chambers.

Claim 37. (WITHDRAWN) Apparatus according to Claim 1, wherein the signal generation circuitry applies the extended pacing signal to the one or more electrodes in response to a demand for an enhancement of hemodynamic performance of the heart.

Claim 38. (WITHDRAWN) Apparatus according to Claim 37, wherein the enhancement of hemodynamic performance comprises an increase in cardiac output.

Claim 39. (WITHDRAWN) Apparatus according to Claim 37, and comprising a sensor which generates an output responsive to a physiological parameter indicative of the demand for the enhancement, wherein the signal generation circuitry applies the extended pacing signal responsive to the output from the sensor.

Claim 40. (WITHDRAWN) Apparatus according to Claim 37, wherein in the absence of the demand for the enhancement, the signal generation circuitry applies pacing pulses to the electrodes of substantially lower energy than the extended pacing signal.

Claim 41. (WITHDRAWN) Apparatus according to Claim 1, wherein the one or more electrodes comprise endocardial electrodes.

Claim 42. (WITHDRAWN) Apparatus according to Claim 1, wherein the one or more electrodes comprise epicardial electrodes.

Claim 43. (WITHDRAWN) Apparatus according to Claim 1, wherein the one or more electrodes comprise transmyocardial electrodes.

Claim 44. (WITHDRAWN) Apparatus according to Claim 1, wherein the one or more electrodes comprise transvenous electrodes.

Claim 45. (WITHDRAWN) Apparatus according to Claim 1, and comprising a sensor, coupled to generate a signal responsive to activity of the heart, wherein the signal generation circuitry receives the signal from the sensor and modifies the extended pacing signal responsive thereto.

Claim 46. (WITHDRAWN) Apparatus according to Claim 45, wherein the sensor comprises an electrode.

Claim 47. (WITHDRAWN) Apparatus according to Claim 46, wherein the electrode senses a Monophasic Action Potential signal.

Claim 48. (WITHDRAWN) Apparatus according to Claim 46, wherein the sensor comprises a pair of closely-spaced bipolar electrodes, which sense a local endocardial action potential.

Claim 49. (WITHDRAWN) Apparatus according to Claim 45, wherein the signal generation circuitry detects a possible arrhythmic stimulation of the heart and modifies the extended pacing signal so as to prevent the arrhythmic stimulation.

Claim 50. (PREVIOUSLY PRESENTED) A method for heart pacing with enhancement of cardiac contraction, comprising:

applying one or more electrodes to a subject's heart; and

conveying an extended pacing signal, having an overall duration greater than 8 ms, to the one or more electrodes so as to pace the heart.

Claim 51. (PREVIOUSLY PRESENTED) A method according to Claim 50, wherein the overall duration is at least 10 ms.

Claim 52. (PREVIOUSLY PRESENTED) A method according to Claim 51, wherein the overall duration is at least 20 ms.

Claim 53. (PREVIOUSLY PRESENTED) A method according to Claim 50, wherein the overall duration is less than approximately 100 ms.

Claim 54. (PREVIOUSLY PRESENTED) A method according to Claim 50, wherein the cardiac muscle segments to which the one or more electrodes are adapted to be applied are characterized by a refractory period, and wherein the overall duration of the signal is such that the signal terminates during the refractory period.

Claim 55. (PREVIOUSLY PRESENTED) A method according to Claim 50, wherein the signal has a leading edge and a trailing edge, and wherein the trailing edge is characterized by an absolute rate of voltage change substantially smaller than that of the leading edge.

Claim 56. (PREVIOUSLY PRESENTED) A method according to Claim 55, wherein the absolute rate of the voltage change is less than a minimum rate of change necessary to generate an action potential in the cardiac muscle segments.

Claim 57. (PREVIOUSLY PRESENTED) A method according to Claim 50, wherein the signal has an amplitude at least three times as great as a threshold for pacing the heart, but not sufficient for cardioversion.



Claim 58. (PREVIOUSLY PRESENTED) A method according to Claim 57, wherein the signal has a duration at least three times a threshold duration for pacing the heart at the amplitude of the signal.

Claim 59. (PREVIOUSLY PRESENTED) A method according to Claim 50, wherein conveying the extended pacing signal comprises conveying a train of pulses.

Claim 60. (PREVIOUSLY PRESENTED) A method according to Claim 59, wherein each of the pulses in the train has a pulse duration of at least 1 ms.

Claim 61. (PREVIOUSLY PRESENTED) A method according to Claim 59, wherein the train of pulses has a period of at least 5 ms.

Claim 62. (PREVIOUSLY PRESENTED) A method according to Claim 61, wherein the train of pulses has a period of at least 20 ms.

Claim 63. (PREVIOUSLY PRESENTED) A method according to Claim 59, wherein conveying the train of pulses comprises conveying a plurality of biphasic pulses.

Claim 64. (PREVIOUSLY PRESENTED) A method according to Claim 59, wherein the train of pulses has a duty cycle between about 10% and 50%.

Claim 65. (WITHDRAWN) A method for heart pacing with hemodynamic enhancement, comprising:

applying one or more electrodes to the heart; and

conveying an extended pacing signal, comprising a train of a plurality of biphasic pulses, to the one or more electrodes so as to pace the heart.

Claim 66. (WITHDRAWN) A method according to Claim 65, wherein each of the pulses in the train has a pulse duration of at least 1 ms.

Claim 67. (WITHDRAWN) A method according to Claim 65, wherein the train of pulses has a period of at least 5 ms.

Claim 68. (WITHDRAWN) Apparatus according to Claim 67, wherein the train of pulses has a period of at least 20 ms.

Claim 69. (WITHDRAWN) A method according to Claim 65, wherein the train of pulses has a duty cycle between about 10% and 50%.

Claim 70. (WITHDRAWN) A method according to Claim 65, wherein conveying the train of pulses comprises conveying square wave pulses.

Claim 71. (WITHDRAWN) A method according to Claim 65, wherein conveying the train of pulses comprises conveying sinusoidal pulses.

Claim 72. (WITHDRAWN) A method for heart pacing with hemodynamic enhancement, comprising:

applying one or more electrodes to the heart; and

conveying an extended pacing signal to the one or more electrodes so as to pace the heart, the signal having an amplitude at least three times as great as a threshold for pacing the heart, but not sufficient for cardioversion.

Claim 73. (WITHDRAWN) A method according to Claim 72, wherein the signal has a duration at least three times a threshold duration for pacing the heart at the amplitude of the signal.

Claim 74. (WITHDRAWN) A method according to Claim 72, wherein conveying the extended pacing signal comprises modifying a characteristic of pulsatile flow of blood in the heart.

Claim 75. (WITHDRAWN) A method according to Claim 74, modifying the characteristic comprises increasing a stroke volume of the heart by at least 5% relative to the stroke volume when the heart is paced with pulses less than 2 ms in duration.

Claim 76. (WITHDRAWN) A method according to Claim 75, wherein increasing the stroke volume comprises increasing the stroke volume by at least 10% relative to the stroke volume when the heart is paced with pulses less than 2 ms in duration.

Claim 77. (WITHDRAWN) A method according to Claim 74, wherein modifying the characteristic comprises modifying a cardiac output of the heart by at least 5% relative to the cardiac output when the heart is paced with pulses less than 2 ms in duration at a pacing rate equal to that of the extended pacing signal.

Claim 78. (WITHDRAWN) A method according to Claim 74, wherein modifying the characteristic comprises increasing a contractility of at least a portion of the heart by at least 10% relative to the contractility thereof when the heart is paced with pulses less than 2 ms in duration.

Claim 79. (WITHDRAWN) A method according to Claim 74, wherein modifying the characteristic comprises decreasing a contractility of at least a portion of the heart by at least 10% relative to the contractility thereof when the heart is paced with pulses less than 2 ms in duration.

Claim 80. (WITHDRAWN) A method according to Claim 74, wherein modifying the characteristic comprises modifying a muscular tension in the heart by at least 10% relative to the tension when the heart is paced with pulses less than 2 ms in duration.

Claim 81. (WITHDRAWN) A method according to Claim 72, wherein conveying the extended pacing signal comprises modifying the duration of an action potential in the respective cardiac muscle segments by at least 10% relative to the duration when the heart is paced with pulses less than 2 ms in duration.

Claim 82. (WITHDRAWN) A method according to Claim 72, wherein conveying the extended pacing signal increases a muscular tension in the respective cardiac muscle segments by at least 50% relative to the duration when the heart is paced with pulses less than 2 ms in duration.

Claim 83. (WITHDRAWN) A method according to Claim 82, wherein conveying the extended pacing signal increases the muscular tension in the respective cardiac muscle segments by at least 100% relative to the duration when the heart is paced with pulses less than 2 ms in duration.

Claim 84. (WITHDRAWN) A method according to Claim 72, wherein applying the one or more electrodes comprises applying a plurality of electrodes in different chambers of the heart.

Claim 85. (WITHDRAWN) A method according to Claim 84, wherein conveying the extended pacing signal comprises conveying a plurality of waveforms respectively to the electrodes in the different chambers according to a predetermined time sequence.

Claim 86. (WITHDRAWN) A method according to Claim 84, and comprising conveying a pacing pulse having a duration less than 8 ms to one or more of the electrodes positioned in a first one of the different chambers, and wherein conveying the extended pacing signal comprises conveying the signal to another one or more of the electrodes positioned in a second one of the different chambers.

Claim 87. (WITHDRAWN) A method according to Claim 72, wherein conveying the extended pacing signal comprises conveying the signal to the one or more electrodes in response to a demand for an enhancement of hemodynamic performance of the heart.

Claim 88. (WITHDRAWN) A method according to Claim 87, wherein the enhancement of hemodynamic performance comprises an increase in cardiac output.

Claim 89. (WITHDRAWN) A method according to Claim 87, and comprising receiving an output signal responsive to a physiological parameter indicative of the demand for the enhancement, and wherein conveying the extended pacing signal comprises conveying the pacing signal responsive to the output signal.

Claim 90. (WITHDRAWN) A method according to Claim 87, and comprising, in the absence of the demand for the enhancement, conveying pacing pulses to the electrodes of substantially lower energy than the extended pacing signal.

Claim 91. (WITHDRAWN) A method according to Claim 72, wherein applying the one or more electrodes comprises applying electrodes endocardially.

Claim 92. (WITHDRAWN) A method according to Claim 72, wherein applying the one or more electrodes comprises applying electrodes epicardially.

Claim 93. (WITHDRAWN) A method according to Claim 72, wherein applying the one or more electrodes comprises applying electrodes transmyocardially.

Claim 94. (WITHDRAWN) A method according to Claim 72, wherein applying the one or more electrodes comprises applying electrodes transvenously.

Claim 95. (WITHDRAWN): A method according to Claim 72, and comprising receiving an output signal responsive to activity of the heart, and wherein conveying the

extended pacing signal comprises modifying the pacing signal responsive to the output signal.

Claim 96. (WITHDRAWN) A method according to Claim 95, wherein receiving the output signal comprises receiving an electrophysiological signal.

Claim 97. (WITHDRAWN) A method according to Claim 96, wherein the electrophysiological signal comprises a Monophasic Action Potential signal.

Claim 98. (WITHDRAWN) A method according to Claim 96, wherein receiving the electrophysiological signal comprises placing a pair of in close mutual proximity in contact with the heart and receiving a bipolar signal from the electrodes.

Claim 99. (WITHDRAWN) A method according to Claim 95, wherein modifying the pacing signal comprises detecting a possible arrhythmic stimulation of the heart and modifying the extended pacing signal so as to prevent the arrhythmic stimulation.

Claim 100. (WITHDRAWN) A method according to Claim 72, wherein applying the one or more electrodes comprises applying electrodes such that conveying the extended pacing signal engenders a redistribution of cardiac muscle mass.

Claim 101. (WITHDRAWN) Apparatus according to Claim 16, wherein application of the extended pacing signal modifies a characteristic of pulsatile flow of blood in the heart.

Claim 102. (WITHDRAWN) Apparatus according to Claim 101, wherein the application of the extended pacing signal increases a stroke volume of the heart by at least 5% relative to the stroke volume when the heart is paced with pulses less than 2 ms in duration.

Claim 103. (WITHDRAWN) Apparatus according to Claim 102, wherein the application of the extended pacing signal increases the stroke volume by at least 10% relative to the stroke volume when the heart is paced with pulses less than 2 ms in duration.

Claim 104. (WITHDRAWN) Apparatus according to Claim 101, wherein the application of the extended pacing signal modifies a cardiac output of the heart by at least 5% relative to the cardiac output when the heart is paced with pulses less than 2 ms in duration at a pacing rate equal to that of the extended pacing signal.

Claim 105. (WITHDRAWN) Apparatus according to Claim 101, wherein the application of the extended pacing signal increases a contractility of at least a portion of the heart by at least 10% relative to the contractility thereof when the heart is paced with pulses less than 2 ms in duration.

Claim 106. (WITHDRAWN) Apparatus according to Claim 101, wherein the application of the extended pacing signal decreases a contractility of at least a portion of the heart by at least 10% relative to the contractility thereof when the heart is paced with pulses less than 2 ms in duration.

Claim 107. (WITHDRAWN) Apparatus according to Claim 101, wherein the application of the extended pacing signal modifies a muscular tension in the heart by at least 10% relative to the tension when the heart is paced with pulses less than 2 ms in duration.

Claim 108. (WITHDRAWN) Apparatus according to Claim 16, wherein application of the extended pacing signal modifies the duration of an action potential in the respective cardiac muscle segments by at least 10% relative to the duration when the heart is paced with pulses less than 2 ms in duration.

Claim 109. (WITHDRAWN) Apparatus according to Claim 16, wherein the signal generation circuitry comprises a pulse generator and a DC offset generator, whose outputs are summed to provide the extended pacing signal.

Claim 110. (WITHDRAWN) Apparatus according to Claim 16, wherein the one or more electrodes comprise a plurality of electrodes, which are positioned in different chambers of the heart.

Claim 111. (WITHDRAWN) Apparatus according to Claim 110, wherein the signal comprises a plurality of waveforms, which are applied respectively to the electrodes in the different chambers according to a predetermined time sequence.

Claim 112. (WITHDRAWN) Apparatus according to Claim 110, wherein a pacing pulse having a duration less than 8 ms is applied to one or more of the electrodes positioned in a first one of the different chambers, and wherein the extended pacing signal is applied to another one or more of the electrodes positioned in a second one of the different chambers.

Claim 113. (WITHDRAWN) Apparatus according to Claim 16, wherein the signal generation circuitry applies the extended pacing signal to the one or more electrodes in response to a demand for an enhancement of hemodynamic performance of the heart.

Claim 114. (WITHDRAWN) Apparatus according to Claim 113, wherein the enhancement of hemodynamic performance comprises an increase in cardiac output.

Claim 115. (WITHDRAWN) Apparatus according to Claim 113, and comprising a sensor which generates an output responsive to a physiological parameter indicative of the demand for the enhancement, wherein the signal generation circuitry applies the extended pacing signal responsive to the output from the sensor.



Claim 116. (WITHDRAWN) Apparatus according to Claim 113, wherein in the absence of the demand for the enhancement, the signal generation circuitry applies pacing pulses to the electrodes of substantially lower energy than the extended pacing signal.

Claim 117. (WITHDRAWN) Apparatus according to Claim 16, wherein the one or more electrodes comprise endocardial electrodes.

Claim 118. (WITHDRAWN) Apparatus according to Claim 16, wherein the one or more electrodes comprise epicardial electrodes.

Claim 119. (WITHDRAWN) Apparatus according to Claim 16, wherein the one or more electrodes comprise transmural electrodes.

Claim 120. (WITHDRAWN) Apparatus according to Claim 16, wherein the one or more electrodes comprise transvenous electrodes.

Claim 121. (WITHDRAWN) Apparatus according to Claim 16, and comprising a sensor, coupled to generate a signal responsive to activity of the heart, wherein the signal generation circuitry receives the signal from the sensor and modifies the extended pacing signal responsive thereto.

Claim 122. (WITHDRAWN) Apparatus according to Claim 121, wherein the sensor comprises an electrode.

Claim 123. (WITHDRAWN) Apparatus according to Claim 122, wherein the electrode senses a Monophasic Action Potential signal.

Claim 124. (WITHDRAWN) Apparatus according to Claim 122, wherein the sensor comprises a pair of closely-spaced bipolar electrodes, which sense a local endocardial action potential.

Claim 125. (WITHDRAWN) Apparatus according to Claim 121, wherein the signal generation circuitry detects a possible arrhythmic stimulation of the heart and modifies the extended pacing signal so as to prevent the arrhythmic stimulation.

Claim 126. (WITHDRAWN) Apparatus according to Claim 23, wherein application of the extended pacing signal modifies a characteristic of pulsatile flow of blood in the heart.

Claim 127. (WITHDRAWN) Apparatus according to Claim 126, wherein the application of the extended pacing signal increases a stroke volume of the heart by at least 5% relative to the stroke volume when the heart is paced with pulses less than 2 ms in duration.

Claim 128. (WITHDRAWN) Apparatus according to Claim 127, wherein the application of the extended pacing signal increases the stroke volume by at least 10% relative to the stroke volume when the heart is paced with pulses less than 2 ms in duration.

Claim 129. (WITHDRAWN) Apparatus according to Claim 126, wherein the application of the extended pacing signal modifies a cardiac output of the heart by at least 5% relative to the cardiac output when the heart is paced with pulses less than 2 ms in duration at a pacing rate equal to that of the extended pacing signal.

Claim 130. (WITHDRAWN) Apparatus according to Claim 126, wherein the application of the extended pacing signal increases a contractility of at least a portion of the heart by at least 10% relative to the contractility thereof when the heart is paced with pulses less than 2 ms in duration.

Claim 131. (WITHDRAWN) Apparatus according to Claim 126, wherein the application of the extended pacing signal decreases a contractility of at least a portion of the heart by at least 10% relative to the contractility thereof when the heart is paced with pulses less than 2 ms in duration.

Claim 132. (WITHDRAWN) Apparatus according to Claim 126, wherein the application of the extended pacing signal modifies a muscular tension in the heart by at least 10% relative to the tension when the heart is paced with pulses less than 2 ms in duration.

Claim 133. (WITHDRAWN) Apparatus according to Claim 23, wherein application of the extended pacing signal modifies the duration of an action potential in the respective cardiac muscle segments by at least 10% relative to the duration when the heart is paced with pulses less than 2 ms in duration.

Claim 134. (WITHDRAWN) Apparatus according to Claim 23, wherein the signal generation circuitry comprises a pulse generator and a DC offset generator, whose outputs are summed to provide the extended pacing signal.

Claim 135. (WITHDRAWN) Apparatus according to Claim 23, wherein the one or more electrodes comprise a plurality of electrodes, which are positioned in different chambers of the heart.

Claim 136. (WITHDRAWN) Apparatus according to Claim 135, wherein the signal comprises a plurality of waveforms, which are applied respectively to the electrodes in the different chambers according to a predetermined time sequence.

Claim 137. (WITHDRAWN) Apparatus according to Claim 135, wherein a pacing pulse having a duration less than 8 ms is applied to one or more of the electrodes positioned in a first one of the different chambers, and wherein the extended pacing signal is applied to another one or more of the electrodes positioned in a second one of the different chambers.

Claim 138. (WITHDRAWN) Apparatus according to Claim 23, wherein the signal generation circuitry applies the extended pacing signal to the one or more electrodes in response to a demand for an enhancement of hemodynamic performance of the heart.

Claim 139. (WITHDRAWN) Apparatus according to Claim 138, wherein the enhancement of hemodynamic performance comprises an increase in cardiac output.

Claim 140. (WITHDRAWN) Apparatus according to Claim 138, and comprising a sensor which generates an output responsive to a physiological parameter indicative of the demand for the enhancement, wherein the signal generation circuitry applies the extended pacing signal responsive to the output from the sensor.

Claim 141. (WITHDRAWN) Apparatus according to Claim 138, wherein in the absence of the demand for the enhancement, the signal generation circuitry applies pacing pulses to the electrodes of substantially lower energy than the extended pacing signal.

Claim 142. (WITHDRAWN) Apparatus according to Claim 23, wherein the one or more electrodes comprise endocardial electrodes.

Claim 143. (WITHDRAWN) Apparatus according to Claim 23, wherein the one or more electrodes comprise epicardial electrodes.

Claim 144. (WITHDRAWN) Apparatus according to Claim 23, wherein the one or more electrodes comprise transmural electrodes.

Claim 145. (WITHDRAWN) Apparatus according to Claim 23, wherein the one or more electrodes comprise transvenous electrodes.

Claim 146. (WITHDRAWN) Apparatus according to Claim 23, and comprising a sensor, coupled to generate a signal responsive to activity of the heart, wherein the signal generation circuitry receives the signal from the sensor and modifies the extended pacing signal responsive thereto.

Claim 147. (WITHDRAWN) Apparatus according to Claim 146, wherein the sensor comprises an electrode.

Claim 148. (WITHDRAWN) Apparatus according to Claim 147, wherein the electrode senses a Monophasic Action Potential signal.

Claim 149. (WITHDRAWN) Apparatus according to Claim 147, wherein the sensor comprises a pair of closely-spaced bipolar electrodes, which sense a local endocardial action potential.

Claim 150. (WITHDRAWN) Apparatus according to Claim 146, wherein the signal generation circuitry detects a possible arrhythmic stimulation of the heart and modifies the extended pacing signal so as to prevent the arrhythmic stimulation.

Claim 151. (PREVIOUSLY PRESENTED) A method according to Claim 50, wherein conveying the extended pacing signal comprises modifying a characteristic of pulsatile flow of blood in the heart.

Claim 152. (PREVIOUSLY PRESENTED) A method according to Claim 151, modifying the characteristic comprises increasing a stroke volume of the heart by at least 5% relative to the stroke volume when the heart is paced with pulses less than 2 ms in duration.

Claim 153. (PREVIOUSLY PRESENTED) A method according to Claim 152, wherein increasing the stroke volume comprises increasing the stroke volume by at least 10% relative to the stroke volume when the heart is paced with pulses less than 2 ms in duration.

Claim 154. (PREVIOUSLY PRESENTED) A method according to Claim 151, wherein modifying the characteristic comprises modifying a cardiac output of the heart by at least 5% relative to the cardiac output when the heart is paced with pulses less than 2 ms in duration at a pacing rate equal to that of the extended pacing signal.

Claim 155. (PREVIOUSLY PRESENTED) A method according to Claim 151, wherein modifying the characteristic comprises increasing a contractility of at least a portion of the heart by at least 10% relative to the contractility thereof when the heart is paced with pulses less than 2 ms in duration.

Claim 156. (PREVIOUSLY PRESENTED) A method according to Claim 151, wherein modifying the characteristic comprises decreasing a contractility of at least a portion of the heart by at least 10% relative to the contractility thereof when the heart is paced with pulses less than 2 ms in duration.

Claim 157. (PREVIOUSLY PRESENTED) A method according to Claim 151, wherein modifying the characteristic comprises modifying a muscular tension in the heart by at least 10% relative to the tension when the heart is paced with pulses less than 2 ms in duration.

Claim 158. (PREVIOUSLY PRESENTED) A method according to Claim 50, wherein conveying the extended pacing signal comprises modifying the duration of an action potential in the respective cardiac muscle segments by at least 10% relative to the duration when the heart is paced with pulses less than 2 ms in duration.

Claim 159. (PREVIOUSLY PRESENTED) A method according to Claim 50, wherein conveying the extended pacing signal increases a muscular tension in the respective cardiac muscle segments by at least 50% relative to the duration when the heart is paced with pulses less than 2 ms in duration.

Claim 160. (PREVIOUSLY PRESENTED) A method according to Claim 159, wherein conveying the extended pacing signal increases the muscular tension in the respective cardiac muscle segments by at least 100% relative to the duration when the heart is paced with pulses less than 2 ms in duration.

Claim 161. (PREVIOUSLY PRESENTED) A method according to Claim 50, wherein applying the one or more electrodes comprises applying a plurality of electrodes in different chambers of the heart.

Claim 162. (PREVIOUSLY PRESENTED) A method according to Claim 161, wherein conveying the extended pacing signal comprises conveying a plurality of waveforms respectively to the electrodes in the different chambers according to a predetermined time sequence.

Claim 163. (PREVIOUSLY PRESENTED) A method according to Claim 161, and comprising conveying a pacing pulse having a duration less than 8 ms to one or more of the electrodes positioned in a first one of the different chambers, and wherein conveying the extended pacing signal comprises conveying the signal to another one or more of the electrodes positioned in a second one of the different chambers.

Claim 164. (PREVIOUSLY PRESENTED) A method according to Claim 50, wherein conveying the extended pacing signal comprises conveying the signal to the one or more electrodes in response to a demand for an enhancement of hemodynamic performance of the heart.

Claim 165. (PREVIOUSLY PRESENTED) A method according to Claim 164, wherein the enhancement of hemodynamic performance comprises an increase in cardiac output.

Claim 166. (PREVIOUSLY PRESENTED) A method according to Claim 164, and comprising receiving an output signal responsive to a physiological parameter indicative of the demand for the enhancement, and wherein conveying the extended pacing signal comprises conveying the pacing signal responsive to the output signal.

Claim 167. (PREVIOUSLY PRESENTED) A method according to Claim 164, and comprising, in the absence of the demand for the enhancement, conveying pacing pulses to the electrodes of substantially lower energy than the extended pacing signal.

Claim 168. (PREVIOUSLY PRESENTED) A method according to Claim 50, wherein applying the one or more electrodes comprises applying electrodes endocardially.

Claim 169. (PREVIOUSLY PRESENTED) A method according to Claim 50, wherein applying the one or more electrodes comprises applying electrodes epicardially.

Claim 170. (PREVIOUSLY PRESENTED) A method according to Claim 50, wherein applying the one or more electrodes comprises applying electrodes transmurally.



Claim 171. (PREVIOUSLY PRESENTED) A method according to Claim 50, wherein applying the one or more electrodes comprises applying electrodes transvenously.

Claim 172. (PREVIOUSLY PRESENTED) A method according to Claim 50, and comprising receiving an output signal responsive to activity of the heart, and wherein conveying the extended pacing signal comprises modifying the pacing signal responsive to the output signal.

Claim 173. (PREVIOUSLY PRESENTED) A method according to Claim 172, wherein receiving the output signal comprises receiving an electrophysiological signal.

Claim 174. (PREVIOUSLY PRESENTED) A method according to Claim 173, wherein the electrophysiological signal comprises a Monophasic Action Potential signal.

Claim 175. (CURRENTLY AMENDED) A method according to Claim 173, wherein receiving the electrophysiological signal comprises placing a pair of bipolar electrodes in close mutual proximity in contact with the heart and receiving a bipolar signal from the bipolar electrodes.

Claim 176. (PREVIOUSLY PRESENTED) A method according to Claim 172, wherein modifying the pacing signal comprises detecting a possible arrhythmic stimulation of the heart and modifying the extended pacing signal so as to prevent the arrhythmic stimulation.

Claim 177. (PREVIOUSLY PRESENTED) A method according to Claim 50, wherein applying the one or more electrodes comprises applying electrodes such that conveying the extended pacing signal engenders a redistribution of cardiac muscle mass.

Claim 178. (WITHDRAWN) A method according to Claim 65, wherein conveying the extended pacing signal comprises modifying a characteristic of pulsatile flow of blood in the heart.

Claim 179. (WITHDRAWN) A method according to Claim 178, modifying the characteristic comprises increasing a stroke volume of the heart by at least 5% relative to the stroke volume when the heart is paced with pulses less than 2 ms in duration.

Claim 180. (WITHDRAWN) A method according to Claim 179, wherein increasing the stroke volume comprises increasing the stroke volume by at least 10% relative to the stroke volume when the heart is paced with pulses less than 2 ms in duration.

Claim 181. (WITHDRAWN) A method according to Claim 178, wherein modifying the characteristic comprises modifying a cardiac output of the heart by at least 5% relative to the cardiac output when the heart is paced with pulses less than 2 ms in duration at a pacing rate equal to that of the extended pacing signal.

Claim 182. (WITHDRAWN) A method according to Claim 178, wherein modifying the characteristic comprises increasing a contractility of at least a portion of the heart by at least 10% relative to the contractility thereof when the heart is paced with pulses less than 2 ms in duration.

Claim 183. (WITHDRAWN) A method according to Claim 178, wherein modifying the characteristic comprises decreasing a contractility of at least a portion of the heart by at least 10% relative to the contractility thereof when the heart is paced with pulses less than 2 ms in duration.

Claim 184. (WITHDRAWN) A method according to Claim 178, wherein modifying the characteristic comprises modifying a muscular tension in the heart by at least 10% relative to the tension when the heart is paced with pulses less than 2 ms in duration.

Claim 185. (WITHDRAWN) A method according to Claim 65, wherein conveying the extended pacing signal comprises modifying the duration of an action potential in the respective cardiac muscle segments by at least 10% relative to the duration when the heart is paced with pulses less than 2 ms in duration.

Claim 186. (WITHDRAWN) A method according to Claim 65, wherein conveying the extended pacing signal increases a muscular tension in the respective cardiac muscle segments by at least 50% relative to the duration when the heart is paced with pulses less than 2 ms in duration.

Claim 187. (WITHDRAWN) A method according to Claim 186, wherein conveying the extended pacing signal increases the muscular tension in the respective cardiac muscle segments by at least 100% relative to the duration when the heart is paced with pulses less than 2 ms in duration.

Claim 188. (WITHDRAWN) A method according to Claim 65, wherein applying the one or more electrodes comprises applying a plurality of electrodes in different chambers of the heart.

Claim 189. (WITHDRAWN) A method according to Claim 188, wherein conveying the extended pacing signal comprises conveying a plurality of waveforms respectively to the electrodes in the different chambers according to a predetermined time sequence.

Claim 190. (WITHDRAWN) A method according to Claim 188, and comprising conveying a pacing pulse having a duration less than 8 ms to one or more of the electrodes positioned in a first one of the different chambers, and wherein conveying the extended pacing signal comprises conveying the signal to another one or more of the electrodes positioned in a second one of the different chambers.

Claim 191. (WITHDRAWN) A method according to Claim 65, wherein conveying the extended pacing signal comprises conveying the signal to the one or more electrodes in response to a demand for an enhancement of hemodynamic performance of the heart.

Claim 192. (WITHDRAWN) A method according to Claim 191, wherein the enhancement of hemodynamic performance comprises an increase in cardiac output.

Claim 193. (WITHDRAWN) A method according to Claim 191, and comprising receiving an output signal responsive to a physiological parameter indicative of the demand for the enhancement, and wherein conveying the extended pacing signal comprises conveying the pacing signal responsive to the output signal.

Claim 194. (WITHDRAWN) A method according to Claim 191, and comprising, in the absence of the demand for the enhancement, conveying pacing pulses to the electrodes of substantially lower energy than the extended pacing signal.

Claim 195. (WITHDRAWN) A method according to Claim 65, wherein applying the one or more electrodes comprises applying electrodes endocardially.

Claim 196. (WITHDRAWN) A method according to Claim 65, wherein applying the one or more electrodes comprises applying electrodes epicardially.

Claim 197. (WITHDRAWN) A method according to Claim 65, wherein applying the one or more electrodes comprises applying electrodes transmyocardially.

Claim 198. (WITHDRAWN) A method according to Claim 65, wherein applying the one or more electrodes comprises applying electrodes transvenously.

Claim 199. (WITHDRAWN) A method according to Claim 65, and comprising receiving an output signal responsive to activity of the heart, and wherein conveying the extended pacing signal comprises modifying the pacing signal responsive to the output signal.

Claim 200. (WITHDRAWN) A method according to Claim 199, wherein receiving the output signal comprises receiving an electrophysiological signal.

Claim 201. (WITHDRAWN) A method according to Claim 200, wherein the electrophysiological signal comprises a Monophasic Action Potential signal.

Claim 202. (WITHDRAWN AND CURRENTLY AMENDED) A method according to Claim 200, wherein receiving the electrophysiological signal comprises placing a pair of bipolar electrodes in close mutual proximity in contact with the heart and receiving a bipolar signal from the bipolar electrodes.

Claim 203. (WITHDRAWN) A method according to Claim 199, wherein modifying the pacing signal comprises detecting a possible arrhythmic stimulation of the heart and modifying the extended pacing signal so as to prevent the arrhythmic stimulation.

Claim 204. (WITHDRAWN) A method according to Claim 65, wherein applying the one or more electrodes comprises applying electrodes such that conveying the extended pacing signal engenders a redistribution of cardiac muscle mass.